

## OPERATION OF THE TEOM AIR SAMPLING SYSTEM

**Purpose** This Meteorology and Air Quality Group (MAQ) procedure describes the setup, operation, and moving of the Tapered Element Oscillating Microbalance (TEOM) air sampling systems.

**Scope** This procedure applies to the operational use of the TEOM to collect ambient particulate data and particulate samples.

**In this procedure** This procedure addresses the following major topics:

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**Hazard Control Plan** The hazard evaluation associated with this work is documented in Attachment 1: Initial risk = **low**. Residual risk = **low**. Work permits required: none. First authorization review date is one year from group leader signature below; subsequent authorizations are on file in group office.

**Signatures**

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10/20/03

### CONTROLLED DOCUMENT

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## General information about this procedure

**Attachments** This procedure has the following attachment:

Number	Attachment Title	No. of pages
1	Hazard Control Plan	3

**History of revision**

This table lists the revision history and effective dates of this procedure.

Revision	Date	Description Of Changes
0	5/28/99	New document.
1	7/30/01	Add HCP as attachment, described hazards from moving TEOM instrument, and added chapter.
2	7/2/02	Quick-change revision to instructions on use of software for downloading data.
3	10/21/03	Add chapter on data storage, reduce filter loading to 75% for filter replacement, remove references to ACCU system, and modify risks in HCP.

**Who requires training to this procedure?**

The following personnel require training before implementing this procedure:

- MAQ personnel assigned to operate the TEOM and collect data and/or samples from the TEOM

**Training method**

The training method for this procedure is **on-the-job** training by a previously trained individual and is documented in accordance with the procedure for training (MAQ-024).

**Prerequisites**

In addition to training to this procedure, the following training is also required prior to performing this procedure:

- First Aid and Cardiopulmonary Resuscitation (CPR)
- MAQ-011, "Logbook Use and Control"
- "General Safety and Security for All"

Periodically review the field safety information in the New Employee Handbook (see MAQ-032).

## General information, continued

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### Definitions specific to this procedure

TEOM: Tapered Element Oscillating Microbalance. This instrument draws ambient air through a filter that is continuously weighed, giving real-time mass concentrations.

PM-10, PM-2.5, and PM-1: Particulate matter with an aerodynamic diameter of  $\leq 10\mu\text{m}$ ,  $\leq 2.5\mu\text{m}$ , and  $\leq 1\mu\text{m}$ , respectively.

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### References

The following documents are referenced in this procedure:

- MAQ-024, "Personnel Training"
  - MAQ-032, "Orienting New Employees"
  - MAQ-011, "Logbook Use and Control"
  - Rupprecht and Patashnick Operating Manual for TEOM
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### Note

Actions specified within this procedure, unless preceded with "should" or "may," are to be considered mandatory guidance (i.e., "shall").

## Instrument overview and worker safety

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### TEOM monitor principles of operation

The TEOM (Tapered Element Oscillating Microbalance) draws ambient air through an inlet (total suspended particles [TSP], PM-10, PM-2.5, or PM-1) at a constant flow rate of 16.7 L/min (0.6 cfm). The flow is split. Three L/min (0.1 cfm) go to a Teflon-coated borosilicate glass filter which vibrates on a hollow tapered element. An electronic control circuit measures and records this frequency of vibration, which decreases as mass increases. The remaining 13.7 L/min (0.5 cfm) are directed to an exhaust stream. Mass concentrations are reported in  $\mu\text{g}/\text{m}^3$  and are corrected for local temperature and barometric pressure. The use of hydrophobic filter material, along with sample collection at 50°C (above ambient temperature) eliminates the need for humidity equilibration. Retrievable data include (but are not limited to) a 10-minute average mass concentration (MC), 30-minute MC, 1-hour MC, 8-hour MC, 24-hour MC, temperature of the mass transducer and the sample stream at the base of the heated air inlet, and actual flows through the main flow controller and through the auxiliary flow controller. An RS-232 output allows a means of transmitting data to a serial printer or a personal computer. Data logging capabilities are available.

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**Worker safety** **DO NOT perform work under conditions you consider unsafe.** Before beginning work described in this procedure, review safety needs and requirements, identify hazards, and develop hazard mitigation measures.

**Stormy weather** - Reschedule or delay work activities as necessary to avoid areas experiencing severe or dangerous weather.

**Electrical equipment** - Work described in this procedure is performed in close proximity to energized equipment. Do not work in the vicinity of exposed conductors.

If electrical conduit or extension cords are damaged, do not touch the unit – instead, call KSL and request repairs.

## Moving and setting up the TEOM

### Moving the instrument

All personnel assisting with the moving of the heavy instrument must wear steel-toed shoes.

The preferred method to move the TEOM is a truck with a lift gate. The TEOM can be walked onto the lift, lifted, then walked into the bed.

Or, the smaller components of the TEOM may be removed from inside the outdoor enclosure, and the bulky enclosure can be tipped onto a piece of material (e.g., cardboard or carpet) in the bed of a pick-up and pushed into the bed.

Or, find a certified fork lift operator and ask him or her to load and/or unload the TEOM.

During transport, the TEOM should be tied down in the pick-up bed.

### Setup at measurement site

At the location where the TEOM will be used, set the instrument on appropriate blocks or other secure footings.

Connect power from a GFCI-protected circuit or extension cord.

### TEOM start-up steps

To begin operation of TEOM, perform the following steps:

Step	Action
1	Check that all components (pump, sensor unit, filter, inlet head and control unit) are in their designated locations. Be sure the control unit is plugged into a surge protector and other electrical units are plugged into the power strip on the inside rear of the outdoor enclosure.
2	Ensure proper electrical connection. <b>Note:</b> The external plug (115 volt) has a special configuration for use on higher-amperage circuits.
3	Set the air conditioner to 80° F and the heater thermostats to 50° F.
4	Press the “Power” button on the Control Unit.
5	Turn on the pump.

*Steps continued on next page.*

## Moving and setting up the TEOM, continued

Step	Action
6	<p>Allow the instrument time to initialize.</p> <p><b>Note:</b> Data collection will not occur until flow rates and temperatures reach tolerance levels and remain stable for 30 minutes. The Main Screen displays a status line that provides information on the initialization process, filter loading, and operational settings. It also displays informational lines that contain averages of mass concentrations, mass accumulation on filter, system temperatures, flow rates, and diagnostic indicators.</p>
7	<p>Check that a filter is installed in the mass transducer. If the filter loading (in percent) as displayed on the main screen is over 75% or will be over 75% before the next service, replace the filter. See the chapter <i>Filter exchange</i> in this procedure.</p>
8	<p>Determine operating parameters as desired by the principal investigator and set them by pressing “Data Stop” and entering “Setup Mode” and following the menus. See the chapter <i>Setting operating parameters</i> in this procedure.</p>

## Setting operating parameters

<b>Overview</b>	Default parameters are set in the TEOM. If the default parameters do not meet your requirements, they may be edited in "Setup Mode." Press "Data Stop" to enter the setup mode. To re-enter operating mode, press "Run." In the setup mode, the user may either use the "Step Screen" button to step through the menu or directly enter a two digit identifier for the screen (followed by the "Enter" key) on which edits will take place. The following sections in this chapter will give the screen identifier code number and the name and function of the screen.
<b>18: Main Screen or "Main/Status"</b>	This screen gives information on the status of initialization, data collection temperatures, flows, filter loading, and password protection level.
<b>19: Set Temps/Flows</b>	Here the temperature to which the air stream is heated may be edited. If edited, these temperatures are generally lowered during winter months. The main flow rates may be adjusted to 3, 2, or 1 L/min. Since the inlet consistently draws 16.7 L/min (0.6 CFM), the auxiliary flow rate changes accordingly. The TEOMs used by MAQ have an ambient temperature cable and sensor installed. An ambient pressure sensor is built into the control units.
<b>13: Set Hardware</b>	Averaging intervals for mass concentration measurements and smoothing frequencies may be adjusted in this screen.
<b>08: View Storage</b>	Stored records may be recalled. These records are not editable. The TEOM can store a record number, date, time, mass concentration averages, and total mass accumulated on the filter. For 8 data fields per record, the storage capacity is about 5 weeks. If the number of data fields is reduced, the storage capacity is increased.
<b>09: Set Storage</b>	Determines which and how many data fields are recorded and the intervals at which the records are stored.
<b>05: Set RS-232 Mode</b>	This screen displays settings for direct communication to a personal computer and on-line printing. This screen is not editable. See the chapter <i>Downloading data</i> in this procedure for more information.

## Filter exchange

### When to change the filter

The filter loading (in percent) is displayed on the main screen. If this value is over 75% or will be over 75% before the next service, replace the filter as described below.

### Steps to exchange the filter

To exchange filters in the mass transducer, perform the following steps:

Step	Action
1	Keep the sample pump running.
2	Press “Data Stop” on the control unit.
3	Open the door of the sensor unit.
4	Open the door of the mass transducer.
5	Using the black knob, swing the mass transducer down. The tapered element stops vibrating.
6	Remove the old filter by inserting the lower tine of the fork of the filter exchange tool (kept inside the mass transducer) under the filter. The upper and lower tines of the fork straddle the hub of the filter. Gently lift <u>straight up</u> on the filter. Do not twist or pull sideways. Discard the used filter.
7	Use the exchange tool to remove a new pre-conditioned filter (warm and dry) from the filter pocket in the mass transducer. Do not touch the filters with your fingers.
8	Insert the hub of the filter directly onto the tapered element and apply downward pressure to set the filter firmly in place.
9	Remove the filter exchange tool without disturbing the filter.
10	Place a new filter in the filter exchange tool and place it in the filter pocket to condition.
11	Using the black knob, gently raise the mass transducer to the closed position and secure the latch.
12	Close and latch the sensor unit door.
13	Press “Run” to return the instrument to collection.
14	After 5 minutes have elapsed, open the mass transducer again and press straight down on the filter with the bottom of the filter exchange tool. This ensures the filter cartridge is properly seated after the temperature has increased.
15	Record in the TEOM logbook the date and time of the visit and briefly describe the changes made to the station. The Project Leader may also request the recording of certain parameters. Make all entries in accordance with the requirements of MAQ-011.

## Data Storage

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### Automatic data downloading

The TEOMs may be set up to deliver data via modem to the base computer at the cave. For set up and details, refer to the R and P Operating Manual Section 10: RPComm Software.

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### Data review

Data may be reviewed for diagnostics purposes, but data are automatically quickly transferred from the base computer to the TEOM folder in "FTPfiles/TEOM/" on the Users drive.

## Downloading data

### Steps to download data to a PC

If the need arises to manually download data from the TEOM to a personal computer (PC), perform the following steps:

Step	Action
1	Use a PC onto which TEOMCOMM software or RPCOMM has been loaded.
2	Connect the 9-to-9 pin cable from the RS-232 port on the monitor to the RS-232 port on the PC.
3	Press the RS-232 key on the TEOM or press "05" and "Enter."
4	Follow the user's manual for either the TEOMCOMM or RPCOMM software to download the data.
5	After the records are downloaded, immediately set the RS-232 protocol on the TEOM to "None." This will ensure the next download begins where the previous one left off.
6	Disconnect the RS-232 cable and exit the program. Return to main TEOM screen and check system operation as described in chapter "Setting operating parameters."
7	Record in the TEOM logbook the date and time of the visit and briefly describe the changes made to the station. The Project Leader may also request the recording of certain parameters. Make all entries in accordance with the requirements of MAQ-011.

## Records resulting from this procedure

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### Records

The following records are generated as a result of this procedure:

- Entries in the TEOM logbook

**Note:** Logbooks are controlled according to procedure MAQ-011, “Logbook Use and Control.”



## HAZARD CONTROL PLAN

1. The work to be performed is described in this procedure.

### **“Operation Of The TEOM Air Sampling System”**

2. Describe potential hazards associated with the work (use continuation page if needed).

Entry into high explosives testing (TA-15, TA-16, TA-49, etc.)

Entry into radiation Areas (TA-54, TA-16, etc.)

Electrical shock in wet conditions or from electrical conduit damaged by vehicle or large animal.

Dropping heavy equipment

Lifting heavy equipment

Injuries from lowering liftgate on pickup (if used): Cut, pinched or broken fingers or hand from lowering/raising lift platform.

3. For each hazard, list the likelihood and severity, and the resulting initial risk level (before any work controls are applied, as determined according to LIR300-00-01, section 7.2)

Entry into high explosives testing (TA-15, TA-16, TA-49, etc.) – Catastrophic / Remote= Low

Entry into radiation Areas (TA-54, TA-16, etc.) – Negligible / Remote = Minimal

Dropping heavy equipment – Critical / Improbable = Low

Lifting heavy equipment – Occasional / Moderate = Low

Electrical shock in wet conditions – catastrophic / remote = low

Lift gate injuries – Critical / improbable = low

Overall *initial* risk: ☐ Minimal ☒ Low ☐ Medium ☐ High

4. Applicable Laboratory, facility, or activity operational requirements directly related to the work:

☒ None ☐ List:

Work Permits required? ☒ No ☐ List:

## HAZARD CONTROL PLAN, continued

5. Describe how the hazards listed above will be mitigated (e.g., safety equipment, administrative controls, etc.):

Entry into explosives areas or radiation areas: Access-controlled areas are posted and not easily entered without permission. Obey all signs and postings.  
Electrical shock in wet conditions: the unit is plugged into GFCI (ground fault interrupts) circuits.  
Electrical shock from damaged electrical conduit via vehicle or large animal: the administrative control requires that the electrical cord be disconnected prior to any further work.  
Dropping heavy equipment: Wear steel-toes shoes when handling heavy equipment.  
Lifting heavy equipment: A truck with a lift gate may be used to transport the TEOM and the TEOM can be "walked" onto the lift, lifted, then walked into the bed.  
Or, the smaller components of the TEOM may be removed from inside the outdoor enclosure, and the bulky enclosure can be tipped onto a piece of material (e.g., cardboard or carpet) in the bed of a pick-up and pushed into the bed. The TEOM should be secured in the pick-up bed.  
One could find a certified fork lift operator and ask him or her to load and/or unload the TEOM.

-- See continuation page --

6. Knowledge, skills, abilities, and training necessary to safely perform this work (check one or both):



Group-level orientation (per MAQ-032) and training to this procedure.



Other → See training prerequisites on procedure page 3. Any additional describe here:  
Training to "General Safety and Security for All" document.

7. Any wastes and/or residual materials? (check one) ☒ None ☐ List:

8. Considering the administrative and engineering controls to be used, the *residual* risk level (as determined according to LIR300-00-01, section 7.3.3) is (check one):



Minimal



Low



Medium (requires approval by Division Director)

9. Emergency actions to take in event of control failures or abnormal operation (check one):



None



List:

For all trips, falls, burns, cuts, electrical shocks and animal related injuries, provide first aid and see that injured person is taken to HSR-2 or the hospital. For any exposed, energized electrical wires, contact JCNNM or the appropriate authority to turn off the power. Follow all site specific emergency plans for any radiation or explosives emergencies.

Signature of preparer of this HCP: This HCP was prepared by a knowledgeable individual and reviewed in accordance with requirements in LIR 300-00-01 and LIR 300-00-02.

Preparer(s) signature(s)

Name(s) (print)

/Position

Date

Signature by group leader on procedure title page signifies authorization to perform work for personnel properly trained to this procedure. This authorization will be renewed annually and documented in MAQ records. Controlled copies are considered authorized. Work will be performed to controlled copies only. This plan and procedure will be revised according to MAQ-022 and distributed according to MAQ-030.

## HAZARD CONTROL PLAN, continued

**Hazard Control Plan continuation page. Give item number being continued.**

### 5. Mitigation (continued)

Injuries from liftgate -- Always use caution when unhinging the tailgate. When lowering the tailgate, stand far enough back to prevent injuries to upper body if tailgate accidentally is dropped. Whenever possible, stand to side after unhinging tailgate and lower from that position.

- Wear gloves and keep all hands fingers out of hinges, cables, and other pinch points on lift. Do not allow anyone who has not been trained to use the lift. Do not make any modifications to the lift that would void warranty or cause it to malfunction. Check all safety devices for proper operation and repair as needed. Close and lock lift in closed position when not being used. Do not leave it unattended in down position. Always stand to side of lift platform while it is being used